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ABSTRACT

Six different energy-saving treatments for large window areas were tested by Tompkins-Cortland Community College (TCCC) to coordinate energy saving with building design. The TCCC building has an open space design with 33,000 square feet of external glass and other features causing heating problems and high energy costs. Phase I of the window-treatment study, initiated in 1977, reviewed traditional and innovative conservation strategies and methods of measuring window treatment effectiveness. Six available window treatments were installed and tested (i.e., Plexiglas, 3M P-19 reflective film, Seco Thermoshade, thermofold drapes, Tuffak-Twinwall, and GE Lexan Sheet). Test areas were selected on the basis of the suitability of the treatment to the locatien, ability of testers to examine effects of the treatment, and preferences of people using the space. Concurrent with Phase I, TCCC prepared a curriculum in energy conservation, making it possible for work-study students to record field data such as temperatures and wind speed. Additionally, TCCC contracted for a mobile thermograph and monitored interior temperatures and heat flow. The six treatments were evaluated in terms of heat flow reduction, maintenance problems, delivery and installation time, cost, and acoustic, visual, and aesthetic concerns. In Phase II, insulating draperies were selected for windows in high traffic areas, and Seco Thermoshades and Plexiglas sheets were selected for low-use, difficult access areas. Tables, graphs, and technical appendices constitute the bulk of the report. (KL)

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Window Treatment Phase I and Other Energy Conservation Measures

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ADDENDA

Reference: Technical Appendix E

Please note that the Technical Appendix 'E' Electrical Use Academic Years 1974-75 to 1981-82 have been corrected upon the receipt of the final (August) electrical bill for 1980-81 and the revised and approved budget for 1981-82. These corrections manifest better savings than originally anticipated and projected.

Window Treatments at TC3
A Report on Energy Conservation Treatments
by Philip E. Donohue, Director, Buildings and Grounds

Because of the great increases in energy costs in the latter half of the 70's, Tompkins Cortland Community College became a giant laboratory for window treatment studies. Six different energy-saving window treatments for the huge window areas at TC3 were tested so that appropriate permanent window treatments could be selected under a Federal grant to save energy without damaging the architectural design of the building.

The TC3 campus, located in Dryden, NY, is designed on the "open space" concept, and is an aesthetic derivative of the "International" or "Bauhaus" school of architecture, which in this case, required large areas of window wall. The building has large open areas and entire walls of glass throughout. In addition, three courtyard areas are punched through the two-story building from floor to ceiling, resulting in additional walls of glass exposed to outside temperatures. The second floor overhangs the first floor on all sides, and three additional courtyards open up this area. The outside windows look out upon the rolling hills and valleys of the southern Fingerlakes region, a view worth preserving. The campus could not have windows bricked in or boarded up. The open space design has provided great flexibility for changing enrollment and use patterns and alterations in building use can be made at low cost.

The campus was designed during the relatively easy energy days of the early 1970's. At the time construction bids were received, November 1971, a moratorium on new natural gas installations caused the College to abandon plans to use gas, for which the building was originally designed, and to choose electric heat instead. Construction started in June 1972, and the College took full occupancy of the 300,000 square foot building in September 1974, just as the first large increases in energy costs were felt.

It was immediately apparent that the budget for electricity would not be sufficient, since the cost per kilowatt-hour of electricity was doubling. That year 1974-75, half of the Buildings and Grounds budget went toward electrical costs, a total of $258,317 out of a total college budget of $2.6 million. The reason for these high energy costs is clear from the design of the building.

The exterior walls of the campus hold 33,000 square feet of glass, all fixed, much of it single-pane tinted glass. Some of these window walls are 16' high and up to 180' long, while individual panes measure up to 10' by 16'. The bulk of the tinted single-pane glass is located under the 55,000 square foot overhang which holds much of the second floor of the campus.

The overhang, or soffit, creates heating problems on both floors. Most first floor windows are in eternal shadow and cannot benefit from solar heat. The soffit also tends to channel the northwest prevailing wind along the first floor window walls and under the second floor. In the wintertime, this current cooled the floors on the soffit to the point that the thermostat temperatures could not be turned down to nighttime levels when the outside air was below 20°F. To alleviate this, seven inches of high-density fiberglass insulation was blown into the soffit. Where the floor was once 50 °F in winter, it is now 60°F. The technical appendix details current and planned energy conservation measures.

The placement of the building, on a hill, and its courtyards creates unusual wind currents. A vortex in the glassed-in courtyards causes snow to "fall" upwards in the winter. The steady winds on the site wear out flags in three months.

One advantage of the interaction of the soffit and winds is that summer cooling costs are neglible. Heating is the problem; TC3's heating season has exceded 8000 degree days.

As a result of these economic, operational, and design problems, energy conservation was the highest priority of the Buildings and Grounds department. Staffing in the department was slim; a superintendent, a heating, ventilation and air conditioning mechanic, and an electronics technician. Hence, a mechanical engineering firm was hired to conduct an energy survey under a grant shared with the State University of New York and the sponsoring counties, Tompkins and Cortland.

At the beginning of the window treatment survey, August 1977, some simple energy conservation strategies had already reduced the College's electrical use. Such ideas as a load shedder to reduce demand peaks, and the elimination of the "graveyard" cleaning shift ultimately resulted in a reduction of more than 40% in energy use. (See Table IX and X) The next step was to concentrate on the exterior surfaces of the building, especially the windows.

While considering existing window treatment strategies, the College searched for new technology. The engineering consultant recommended the use of 3M brand P-19 plastic film. Storm windows were another possible treatment for the first floor window walls, but these would have to be applied on the interior because of the unusual shapes and sizes of glass, and because the windows have an exterior neoprene glazing strip mounted on steel mullions. Still interior storms would have been expensive.

Nevertheless, Window Treatment Phase I was created in 1977, proposing interior storm windows to cover existing glazing. At the same time, the technology was growing; new products were coming on the market and terms like "window treatment" gained currency. After discussion with the engineering consultants and the architects, TC3 concluded that not enough information was available to make valid judgments on specific window treatments.

In addition, the methodology of measuring window treatment effectiveness was being questioned. Payback time on investments in window treatments was hard to measure.

When storm windows were costed out, it was discovered that they had a longer payback time than some of the newer treatments coming on the market. Further, the administration informed the State University of New York, the College Board of Trustees, and the Buildings and Grounds committee that it was difficult to decide on a single window treatment.

As a result, Window Treatment Phase I became a demonstration project with a variety of the available window treatments installed and tested by the College. This project helped provide information for Window Treatment Phase II, which is the permanent energy conservation installations. The College felt that

this project would serve the community as well as the institution, since the community would be able to benefit from the College's experience with different types of window treatments, especially those which were new to the market. Many inquiries have been received already from other institutions.

Different locations in the building invited tests of different treatments, based on both suitability of the material to the location, and the College's ability to test the effects of the treatment at the location. For example, drapes were placed in a suite of faculty offices at the top of a large, open stairwell, muffling some of the sounds transmitted from the stairs. In another instance, suitability of a test space was determined by the potential for abuse or vandalism.

On exterior glass doors, the 3M reflective film was chosen, to maintain visibility and make the doors more resistant to shattering, both safety concerns.

In choosing the window treatments, the Buildings and Grounds department also considered the preferences of people using the individual areas. For some specific academic activities, it was determined that the 3M film would not be suitable.

Another consideration on matching materials to space was choosing the materials which promised the best resistance to heat transfer, for areas hardest to heat. For example, the Business Office sits on the overhang at the northwest corner of the building. Even with the heating systems running full bore, this area could not be heated to habitable temperatures on cold winter mornings. The thermoshades were installed here, allowing occupants to take advantage of sunny days by rolling up the shades. On other north-facing elevations, the reflective film was used, retaining the transparency of the glass where solar gain was minimal.

In this way, the location for each separate treatment was carefully chosen. Bidding and purchasing regulations limited the number of treatments which could be installed and tested because the materials for the window treatments had to be in place during the winter months. Six separate treatments were installed, five were tested, although many others were examined for suitability, including exterior shutters, window quilts, roll-up layered shades, fixed fiber panels, and a product incorporating sliding fiberglass panels.

Since the College is a public building, code considerations dealing with smoke development, combustibility, and other safety factors were used in choosing the materials.

Those in place include:

1. "Plexiglas," a clear ¼' acrylic sheet
2. 3M P-19 reflective film, to reflect radiant heat inward
3. Seco Thermoshade, interior roll-up window shutters with a hollow core
4. Thermofold drapes, a fire-safe fabric of two woven layers of fiberglass, installed on two tracks
5. Tuffak-Twinwall, honeycombed, clear polycarbonate, ¼" thick
6. GE Lexan sheet, .005" thick acrylic

(See the technical appendix for additional data on these treatments).

At the same time Window Treatment Phase I was conducted the College was preparing a curriculum for courses in energy conservation techniques. Through a federal grant, various measuring equipment was ordered. Two workstudy students, interested in energy conservation, used the instruments to record field data at various outside temperatures and wind speeds. (See Table I)
The testing was supervised by the Director of Buildings and Grounds.

The two instruments used were the Instatherm heat scanner, a non-contact device which allows the user to instantaneously determine the temperature of a surface, and a heat flow probe, which attaches to a surface to measure actual heat flow, rather than temperature, in BTU's per hour per square foot. (See the technical appendix for further specifications on this equipment.)

In addition, a "van scan" or continuous mobile thermograph was conducted by Daedalus Enterprises, Ann Arbor, Michigan, on the evening of January 30, 1980. During the van scan of the exterior, a crew from Buildings and Grounds simultaneously measured and recorded all internal temperatures.

The thermographic study of window treatments scanned all vertical surfaces. As a control for accuracy, and to provide references, two separate scans of the building were made at different angles and distances. Daedalus presented the thermographic data in various thermal references to improve interpretation. One set of scans was in continuous black and white tones. The other was printed in five sets of color references in variuos thermal ranges varying from -14 C to 11.5 C. During the scan, the window heaters were on at the location of the Tuffak treatment, negating thermographic findings. (Specifics on "van scan" measurements are in the technical appendix.)

Surface temperatures were also recorded using the instatherm, but they are not included in this report because of anamolies, caused by emissivity. (Test results will be issued by addendum.)

The attached tables outline the test results, but the methods employed, hand-held instruments, admitted some error. The tendency of warm air to form a pocket at the top of the loose window treatment created a problem in field testing. Draperies particularly exhibited this. They create a chimney of air resulting in a warmer temperature reading at the top. The tight valance of the Thermoshade, on the other hand, restricted this air flow.

"Black body" references were not used, explaining the high R readings on the glass side. These references are difficult to determine in the field. The results of the heat flow probe tests are summarized in Table II, the results for specific treatments in Tables III-VIII. The tables are laid out to illustrate the incremental decrease in 'R' as the instrument moved outside of the building. Because of the convoluted surfaces of the draperies, some difficulty was experienced in the use of the probe on this treatment.

With the probe, the College found R-values of the window walls increased three-fold by most treatments, and up seven-fold in some cases.

The Seco Thermoshade, measured at two separate locations, showed R-values of 3.5 to 5.75, or a heatflow reduction of 70-75%.

The drapes performed better than advertised in some cases, showing a range of 2.3 to 4.4R, a 55-65% reduction in heat flow.

Tuffak-Twinwall carried R-values of 3.3 to 7.3, at least a 70% reduction in heat flow.

Plexiglas showed a 3.3 to 3.9 R-value, again a 70% reduction in heat loss.

Although a full set of emissivity tests was made on the P-19 film, these results are not included because the results cover only the radiant energy aspects.

With the "van scan" the College found colder surface temperatures in the treated windows, again indicating reduced heat loss. At the thermoshade on the northwest corner (Business Office), the outside temperature was 3°- 5°C colder than adjacent untreated areas of similar indoor temperatures. On the first floor, the drapery-treated glass showed 5°- 6° colder than the untreated glass, except at the top center portion of the drape, where warm air pocketed. The Thermoshade on the first floor west-facing window produced 3°C - 4°C colder glass surfaces than untreated areas, except where draft slots had been left for the window heaters, which sent the thermograph off all scales. Plexiglas surfaces were 2°C - 5°C colder than the untreated surfaces with equivalent interior temperature. Because of the window heater, Tuffak readings were off the scale.

All treatments showed maintenance problems. The P-19 film was easily scratched or broken, subject to graffiti and vandalism. It was difficult to clean, and because it reflects light, the film prevented security forces from seeing out from lighted rooms at night.

Similar cleaning problems occured with the lexan, plexiglas and tuffak twinwall. Conventional window cleaning methods, ammonia, water and squeegees, were either difficult or inadvisable. These treatments incurred extra cleaning costs. Although newer cleaning methods are being developed by the plastics industry, none are competitive at this time.

The major problem with the thermoshades was deflection of the slats. When warped or deflected, the shades become difficult to operate because they strain on the jamb hardware. In addition, the shade no longer rests flush on the sill, but leaves a ¼" gap where it is warped. In one case, imprecise milling of the slats caused separation of the shade, which is difficult to reassemble. In the first floor installation, sash cords were used to move shades, but sometimes the cords broke. The sash cord is continuous, heat-welded, and is difficult for the ordinary maintenance worker or custodian to repair.

Overall the thermoshades were well-engineered and roll up and down easily. In situations where users will take reasonable care and caution in their use, the shades will have negligible problems in operation.

The biggest problem with the drapes is their tendency to stretch. In one case they blackened slightly on the window heaters. The College discovered that if the drapes are cut to compensate for this, a gap is left at the sill. In any event, drapes do not fit tightly at jambs, sill, mullions, heads or valances. Yet, this is the nature of the treatment. To correct this might inhibit the advantage of easy operation, since occupants' ease in operating the draperies was found to improve the effectiveness of the treatment.

Users were not intimidated by drapes. There have been no problems in operation, and users show no reluctance in using them. On the other hand, maintenance staff and building users showed some reluctance to operate the Thermoshades.

Another factor to consider in evaluating the window treatments is delivery and installation time. The drapes were delivered and installed within one month of order. Other materials took up to six months from the time of order to installation. Timely delivery and installation allows for an immediate realization of payback and in some cases could affect payback rates by as much as a full year in just a single heating season.

The draped areas "feel" more comfortable than numerical test readings indicate. Whether or not this is a psychological phenomenon, having to do with the esthetic warmth of drapes is a matter of speculation.

Cost of materials depends on the scope of the project, size of sash, and relative complexity of installation. Here is the range of prices per square foot for each material:

		R-range
Clear acrylic plexiglass	$5.25-$6.00	3.3 - 3.9
Tuffak-Twinwall	$6.50-$7.00	3.3 - 3.7
Draperies	$3.25-$4.00	2.3 - 4.4
Thermoshade	$5.50-$7.00	3.5 - 5.75
P-19 reflective film	$1.15-$1.70	-

Each individual window project is unique, so the above ranges can be used only as estimates. Actual prices will reflect the specific location and project. Prices quoted are for fall and winter of 1979.

The College calculated the savings in electrical costs based on various window treatments, as shown in the technical appendix. The immediate savings of these treatments are realized from elimination of the electrical load to supply the window heaters which are draft barriers. These strip heaters, placed 1/3 of the way between floor and ceiling along the width of the window, are designed to eliminate drafts on the window walls. Window treatments have cut down on or eliminated the use of these resistance heaters.

The facts, tests, and observations above, coupled with accepted manufacturer test data established the basis for the Window Treatment Phase II grant. The "simple payback", overall 1.97 years for this proposed energy grant, was calculated as shown in the appendix, allowing the College to justify the grant. The simple payback, in years, can be used for most similar projects to calculate return on investments.

In this energy grant, the College chose to request installation of the insulating draperies in a large dining hall where the view and acoustics are primary considerations, and at interior and exterior courtyards. In addition to the acoustics and visual concerns, esthetics were also considered. As discussed

above, users seemed more relaxed using draperies. This "human element" plays a large role in energy conservation measures at the College. There is a firm resolution to avoid the dreary aspects of energy conservation. Drapes, unlike many other treatments, are part of the room furnishings and decor, adding a element of prestige to the space.

Since unused window treatments reduce payback, and since drapes were used because people are familiar with them, they were deemed the best choice for window areas.

The Seco Thermoshade or equivalent was chosen for areas requiring a higher R-factor, where operation was limited to custodians, security and maintenance staff, or where solar piggybacking could be used.

The plexiglas acrylic sheet will be used on glazed door transoms and areas of difficult access.

Taken together, the energy conservation efforts at TC3 have stabilized energy budget even in the face of increasing costs for electricity.

EXPLANATION OF NOTATIONS ON TABLES

i	=	inside temperature
o	=	outside temperature
Pi	=	heat probe placed on treatment from inside
Po	=	heat probe placed on glass outside
*	=	heat probe inside and outside
**	=	heat probe (inside)
***	=	heat probe (outside)
ΔT	=	diference in temperatures outside-inside ambient

*1 = Result of tests when the average of all probe readings taken from the INSIDE of the treatment are included and when both inside and outside temperature readings were taken.

*2 = Result of tests when average of all probe readings taken from the OUTSIDE of the glass were included and when both inside and outside temperature readings were taken.

*3 = Result of tests when the average of all probe readings are included and when both inside and outside temperature readings were taken.

io	=	Test result averaging inside only readings
oo	=	Test result averaging outside only readings
Avg. i	=	Test result of cummulative inside readings
Avg. o	=	Test result of cummulative outside readings
Avg. i+o	=	Test result of cummulative inside-outside readings

R = Resistance to heat flow: (hr ft.^{2} F°) BTU

Notes:
Degree days are calculated by subtracting the average temperature for that particular day from 65°, the result being the number of heating degree days for that particular day. If temperatures are above 65°, degree days are calculated by subtracting 65° from the temperature, the result being the number of cooling degree days.

Blackbody radiation is defined as the radiation emitted by an object which totally absorbs all incident radiation without reflecting or transmitting any of that energy. Radiation emitted by such an object is greater in total energy than that from any other object at the same temperature. Since real physical objects do not meet the ideal requirements of a theoretical blackbody, the emissivity factor is used to express this difference numerically. Emissivity is the ratio between the energy emitted by the surface of interest and energy emitted by a blackbody at the same temperature.

TABLE I

TEST	DATE	CONDITIONS
A	1-23	Moderate wind
B	1-30	Windy
C	1-30	Windy
D	1-30	Windy
E	2-18	Calm
F	3-13	Rain, no wind
G	3-25	Calm
H	3-27	Clear, partly cloudy
I	4-1	Hazy
J	4-2	Calm
K	4-3	Calm
L	4-4	Very windy
M	4-6	Variable winds; winds increased during outside measurements,
N	4-7	Variable winds
O	4-8	Variable winds
P	4-10	Calm
Q	4-14	Very windy; rain
R	4-17	Calm
S	4-18	Calm
T	no date recorded	Overcast
U	Heat Gain	Sunny Hazy
V	insufficient data	
W	1-22, not all material in place	Cloudy, moderate wind
X	1-20-81	Clear, no wind

TEST	DATE	CONDITIONS
X	1-15-81	No wind
Y	1-6-81	increasingly mild
Z	1-7-81	strong wind
AA	1-8-81	cold, clear, no wind
BB	1-12-81	cold, clear
CC	1-14-81	cloudy, no wind
DD	1-15-81	no wind
EE	1-19-81	clear, no wind to slightly windy
FF	1-20-81	clear, cold, no wind
GG	1-21-81	clear, no wind

Note #1: Where tests are sub-divided by number (i.e., B_2) it indicates that more than one student participated in the test and that they took separate readings at different times during the same evening.

Note #2: Inside and outside ambient temperatures vary from location to location and from treatment to treatment on the same evening because separate readings were taken at each separate location simultaneous with the probe reading for accuracy.

TABLE II
SUMMARY OF TEST RESULTS

		Pi	P	Po	ΔT	R
Drapes	*1	9.78			33.48	3.42
	*3		11.29		33.48	2.97
	*2			12.79	33.48	2.62
	io	10			42.8	4.38
	avg. i	9.8			35.89	3.66
	avg. i + o		11.72		35.89	3.06
	avg. o			13.66	35.89	2.63
	oo			23.75	54.5	2.29
THERMO-SHADES (Red Cubicle)	*1	7.02			33.79	4.81
	*3		8.37		33.79	4.04
	*2			9.72	33.79	3.48
	io	6.25			36.15	5.78
	avg. i	6.97			33.96	4.87
	avg. i + o		8.35		33.96	4.07
	avg. o			9.72	33.96	3.49
	oo					
THERMO-SHADES (Pool Lounge)	*1	8.77			33.62	3.83
	*3		9.67		33.62	3.48
	*2			10.57	33.62	3.18
	io	8.0			45.26	5.66
	avg. i	8.64			36.15	4.18
	avg. i + o		9.62		36.15	3.76
	avg. o			10.59	36.15	3.41
	oo			11.0	54.0	4.91
PLEX (Purple Lounge)	*1	8.52			33.41	3.92
	*3		9.19		33.41	3.64
	*2			9.85	33.41	3.39
	io		No Data			
	avg. i		No Data			
	avg. i + o		No Data			
	avg. o		No Data			
	oo		No Data			
TUFFAK	*1	9.08			34.71	3.82
	*3		9.7		34.71	3.58
	*2			10.32	34.71	3.36
	io	8.0			59.0	7.38
	avg. i	9.04			35.61	3.94
	avg. i + o		9.68		35.61	3.68
	avg. o			10.32	35.61	3.45
	oo		No Data			
PLEX (Blue Study)	*1	10.71			35.56	3.32
	*3		10.81		35.56	3.29
	*2			10.91	35.56	3.26
	io	13.6			49.65	3.65
	avg. i	10.91			37.03	3.39
	avg. i + o		11.02		37.03	3.36
	avg. o			11.12	37.03	3.33
	oo			16.5	58.0	3.52

TABLE III
DRAPES

	i	o	Pi	Po	(*)
A_1	68°	24°	-	-	
B_1	63°	8°	19	25	*
B_2	62°	8°		23	***
C	64°	8°	15	-	**
D	63°	8°	-	24.5	***
E	66°	28°	12	10	*
F	65°	33°	9	-	**
G	66°	35°	23	22	*
H	68°	32.5	13	18	*
I	67°	43°	9	15	*
J	65°	44°	9	10	*
K	68°	45°	7	10	*
L	65°	37°	10	10	*
M	64°	58°	5.1	7.5	*
N	64°	52°	7.8	10	*
O	64°	52°	6.4	11.5	*
P	65°	45°	8.5	11	*
Q	66°	46°	10	10	*
R	66°	42°	9.3	14.5	*
S	69°	50°	14	10	*
T	64.3°	24°	6	-	**
U	-	-	-	-	*
V	-	-	-	-	*
W	-	-	-	-	*
X	63	-	-	-	-
Y	67	20	10	6	*
Z	59	7	8	18	*
AA	64	5	9	19	*
BB	65	0	9.5	17	*
CC	63	19	7	15	*
DD	64	25	6.5	9.5	*
EE	63	29	6.5	10	*
FF	66	20	7.5	9	*
GG	67	18	7.5	9	*

TABLE IV
RED STUDY LOUNGE
"SECO THERMOSHADE"

	i	o	Pi	Po	(*)
A	-	24	-	-	
B_2^1	64	8	7	13	*
B	64	8	6	13	*
C	-	8	-	-	
D	-	8	-	-	
E	65	28°	10	10	*
F	65	33	7	-	**
G	65	35	8	9	*
H	66	32.5	7.4	10	*
I	68	43	6	6.7	*
J	66	44	5.3	9.8	*
K	67	45	5.5	5.7	*
L	65	37	4.5	8.3	*
M	65	58	2.3	7.3	*
N	64	52	3.3	8.5	*
O	66	52	2.8	11	*
P	66	45	4.5	11	*
Q	66	46	5	5	*
R	67	42	6.5	7.3	*
S	69	50	3.5	10	*
T	64.3	24	5.5	-	**
U					
V					
W		24°			
X	63	14	9	8	*
Y	63	20	10	9.5	*
Z	57	7	8	12	*
AA	64	5	9.5	12	*
BB	63	0	16	19	*
CC	55	19	8.5	10	*
DD	64	25	8	9	*
EE	60	30	7.5	9	*
FF	58	20	9	8.5	*
GG	63	19	9.5	10	*

TABLE V
POOL LOUNGE
"SECO THERMOSHADE"

	i	o	Pi	Po	(*)
A_1	68	24	5		**
B_2	62	8	11		**
B_3	62	8	12	10	*
	62	19	11	17	*
C	63	8	10	-	**
D	62	8	-	11	***
E	66	28	10	11	*
F	66	33	8.5	-	**
G	66	35	10	10	*
H	66	32.5	8.2	9	*
I	65	43	8	8	*
J	66	44	6.5	9.2	*
K	66	45	5.9	8.3	*
L	66	37	7.5	10	*
M	66	58	3.5	4.8	*
N	66	52	5.5	9.7	*
O	68	52	4.6	10.8	*
P	67	45	6	11	*
Q	68	46	10	5.5	*
R	64	42	7	8.5	*
S	70	50	10	12.5	*
T	64.3	24	5.5	-	**
U	-	-	-	-	
V	-	-	-	-	
W	-	-	-	-	
X					
Y	63	20	10	10	*
Z	57	7	9	18	*
AA	64	5	11	12	*
BB	63	0	16	20	*
CC	62	19	9	10	*
DD	65	25	9.5	9.5	*
EE	64	30	10	10.5	*
FF	65	20	9	9	*
GG	65	19	10	10	*

TABLE VI
PURPLE STUDY AREA
¼" ACRYLIC SHEET

	i	o	Pi	Po	(*)
A	68	24			
B	60	8	12	14	*
C	62	8	10		*
D	65	8	14.5		*
E	67	28	10	10.5	*
F	65	33	6.5	10	*
G	66	35	10	12	*
H	67	32.5	8.2	8	*
I	68	43	7	7.5	*
J	65	44	5	8.7	*
K	68	45	5.5	7.1	*
L	65	37	5.5	10	*
M	65	58	4.0	4.7	*
N	65	52	6.5	9.8	*
O	65	52	1.8	11	*
P	65	45	4.8	5.1	*
Q	67	46	5	4.5	*
R	67	42	8	7.8	*
S	70	50	2.5	10	*
T	64.3	24	14.2		*
U	-	-	-	-	*
V	-	-	-	-	
W	-	-	-	-	
X	63	14	10	11	*
Y	60	20	8	9.5	*
Z	58	8	10	15	*
AA	60	5	10	12	*
BB	65	0	20	18	*
CC	56	19	10	10	*
DD	58	26	9	10	*
EE	57	30	9	10	*
FF	59	20	9	10	*
GG	58	19	11	10	*

TABLE VII
BLUE CONFERENCE ROOM
¼" ACRYLIC SHEET

	i	o	Pi	Po	(*)
A	-	24	-	-	
B	68	16	14	16	*
C	67	8	13	-	**
D	58	8	-	16.5	***
E	65	28	13	12	*
F	65	33	11	10	*
G	65	35	10	10	*
H	69	32.5	12	9	*
I	65	43	10	10	*
J	65	44	10	10	*
K	69	45	8.5	8.8	*
L	65	37	9	9.1	*
M	65	58	7.5	7.5	*
N	65	52	9.5	9	*
O	65	52	7.6	7.5	*
P	65	45	9.8	7.8	*
Q	68	46	10	10	*
R	64	42	9.5	9.5	*
S	70	50	9	9.5	*
T	64.3	24	14.2	-	**
U	-	-	-	-	
V					
W					
X	67	14	11	11	*
Y	62	20	10	10	*
Z	63	9	10	14	*
AA	62	5	10	18	*
BB	72	0	19	17	*
CC	74	19	18	15	*
DD	73	26	10	11	*
EE	72	30	10	10	*
FF	72	21	10	11	*
GG	72	20	10	11	*

TABLE VIII
TUFFAK TWIN WALL ORANGE CUBICLE

	i	o	Pi	Po	(*)
A	-	24	-	-	
B	66	14	9.2	11	*
C	67	8	8	-	**
D	64	8	-	-	
E	65	28	8	10	*
F	65	33	6.2	10	*
G	65	35	15	13	*
H	66	32.5	11	15	*
I	66	43	8	7.2	*
J	67	44	6.8	10	*
K	70	45	5.7	9.2	*
L	66	37	6	10	*
M	65	38	1.7	3.8	*
N	66	52	4.5	6.5	*
O	66	52	4	6	*
P	67	45	5	8.3	*
Q	67	46	5.5	4	*
R	65	42	8	7.7	*
S	70	50	6	10.5	*
T	64.3	24	-	-	
U	-	-	-	-	
V	-	-	-	-	
W	-	-	-	-	
X	65	15	10	12	*
Y	63	20	10	10	*
Z	62	9	9.5	14	*
AA	67	5	20	17	*
BB	67	0	21	20	*
CC	68	19	14	10	*
DD	67	26	10	10	*
EE	68	30	9	10	*
FF	69	21	11	11	*
GG	66	20	11	12	*

TABLE IX

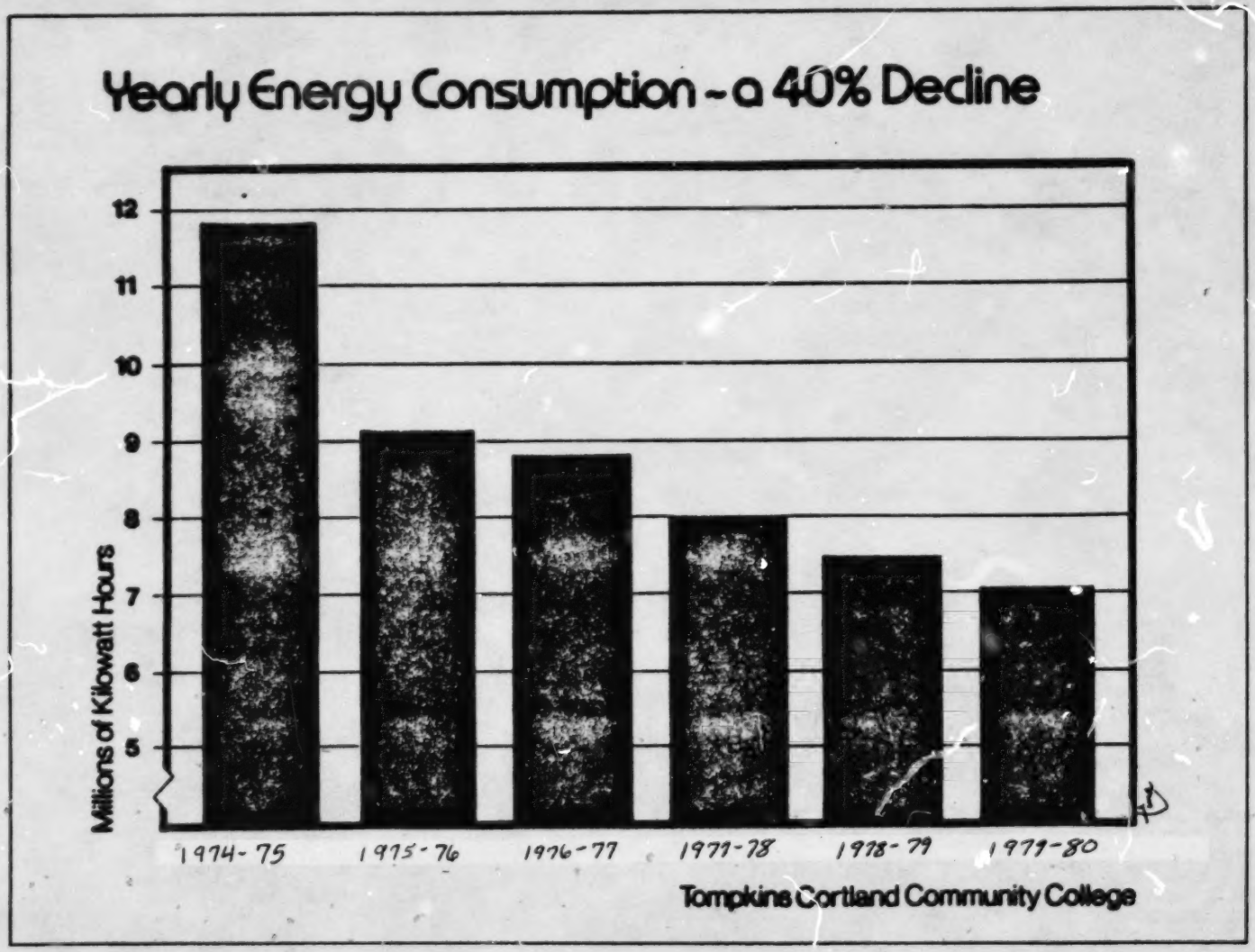
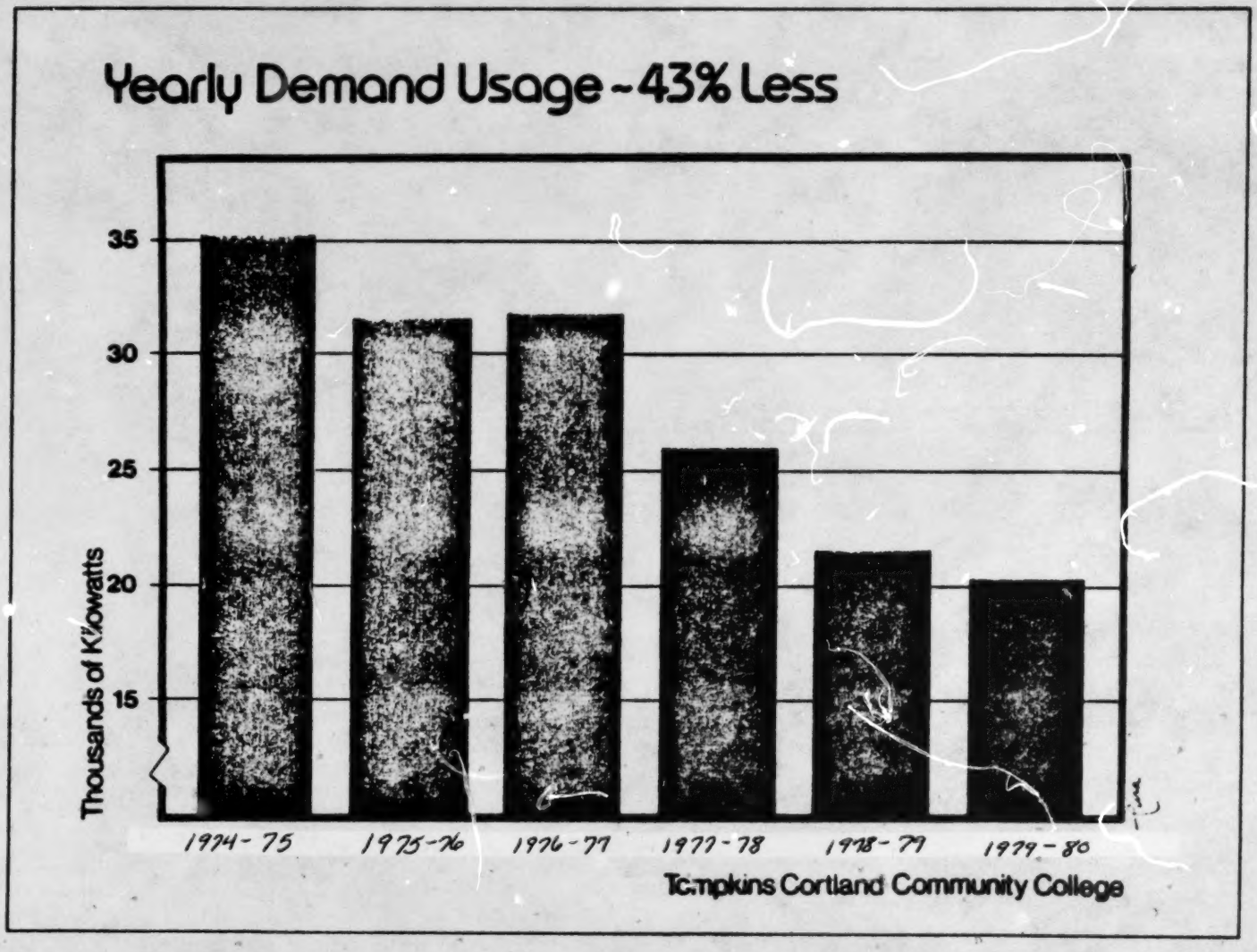

Yearly Energy Consumption - a 40% Decline
Millions of Kilowatt Hours
12
11
10
9
8
7
6
5
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
Tompkins Cortland Community College

TABLE X


Yearly Demand Usage ~ 43% Less
Thousands of Kilowatts
35
30
25
20
15
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
Tompkins Cortland Community College

Red

TECHNICAL APPENDIX A

TREATMENT SPECIFICATIONS

1. Plexiglass: clear, ⅛" thick acrylic, manufactured by Polycast Technologies, Corp., Stanford, CT, 06902.

2. Reflective Film: 3M P-19 insulating film, to reflect radiant heat inward, manufactured by Energy Control Products, 3M Company, 3M Center Bldg., 207, St. Paul, MN, 55101.

   Among other manufacturers that make similar or equal reflective film products include:

   Martin Processing, Inc., Box 5068, Martinsville, VA, 24112.

   Solar-X Corporation, 25 Needham St., Newton, MA 02161

   Madico, 64 Industrial Parkway, Woburn, MA 01801

3. SECO "Thermoshade" - rolling, hollow insulating interior window shutters, manufactured by: Solar Energy Components, Inc., 212 Welsh Pool Rd., Lionville, PA 19353

4. "Thermofold Drapes" fire-safe fabrics: with double track fiberglass, woven and installed in two layers, manufactured by: T. W. Rafferty, Inc., Box 3721, Hartford, CT, 06103

5. "Tuffak-Twinwall" - honeycombed, clear polycarbonate, ⅛" thick, hollow channeled, insulating sheets, manufactured by ROHM and HAAS, Box 73, 1800 Penfield Rd., Penfield, NY, 14526.

   Another window treatment that is presently being installed, but that lacks test data is:

6. Lexan Sheet: .005" thick acrylic, manufactured by GE

TECHNICAL APPENDIX B

TESTING EQUIPMENT SPECIFICATIONS

1. Heat Scanner: Instatherm model #14-220-7, manufactured by Barnes Engineering Co., 30 Commercial Rd., Stanford, CT. This is a portable device, hand-held, true-sighting, non-contact. It allows the user to scan a wall section to instattaneously determine temperature of a surface. It is useful for determining gaps in insulation, air infilitration, stud locations, and the like. This particular model reads absolute temperature to a precision of ½° C, and puts out an audio signal so that several students can monitor the results simultaneously.

2. Heat Flow Probe: with sensor and analog meter, model #HFP-10, manufactured by Concept Engineering, 43 Ragged Rock Road, Old Saybrook, CT, 06475. This device attaches to a surface to measure actual heat flow, not just temperature, in BTU per hour per square foot. This can be used either with the temperature sensing devices described above or independently to estimate building heat losses, insulation efficiency, radiation effects, and in this case, window treatments.

TECHNICAL APPENDIX C

"VAN SCAN CONTINUOUS MOBILE THERMOGRAPH

- Black and white sets
- Color

Set #1	-14°C to -2°C in 2° increments
Set #2	- 2°C to 10°C in 2° increments
Set #3	- 5.5°C to 11.5°C in 3° increments
Set #4	-11°C to 1°C in 2° increments
Set #5	-14°C to 10°C in 4° increments

TECHNICAL APPENDIX D

OTHER ENERGY CONSERVATION MEASURES

1974-75	1.	Abandoned automatic controls that caused hot decks and cold decks of the multi-zones to "combat."
1975-76	1.	Reduced thermostat settings.
	2.	Commenced compressing cleaning shifts.
	3.	Eliminated some outside lighting.
1976-77	1.	Expanded night set back.
	2.	Reduced air flows during winter months.
	3.	Reduced hot water flows.
1977-78	1.	Phase I of demand control.
	2.	Replaced incandescent light fixtures with flourescent light fixtures in stairwells.
	3.	Reduced outside air intake quantity.
	4.	Improved low voltage light switching.
1978-79	1.	Added caulking at exterior.
	2.	Delamped some areas.
	3.	Phase II demand control
1979-80	1.	Commenced Window Treatment Phase I
1980-81	1.	Completed duty cycling of fans.
	2.	Completed styrofoam IRMA roof insulation project.
	3.	Completed soffit insulation.
	4.	Scheduled to complete light modifications.
	5.	Scheduled to complete Window Treatment Phase II.

TECHNICAL APPENDIX E

Note: * ~~Updated year end projection~~
** Budget ~~Estimate~~ Actual

Tompkins Cortland Community College

Electrical Use Academic Years 1974-75 to 1981-82

Year	Total KWH	Total Cost/yr.	Ave. Cost per KWH	FTE	Cost Per FTE
1974-75	11,844,000	$230,906	$.0195	1358.6	169.96
1975-76	9,198,000	$243,423	$.0265	1785.2	136.36
1976-77	8,843,625	$261,306	$.0295	1763.3	148.19
1977-78	8,001,000	$259,132	$.0324	1703.9	152.08
1978-79	7,544,250	$248,810	$.0330	1778.8	139.88
1979-80	7,032,375	$250,788	$.0357	1893.5	132.45
Actual * 1980-81	6,591,375 ~~6,825,000~~	$264,601 ~~$266,175~~	$.0401 ~~$.0390~~	1897.1 ~~1930.~~	139.48 ~~137.91~~
**1981-82	5,637,833 ~~6,250,000~~	$270,616 ~~$287,500~~	$.048 ~~$.040~~	1950	138.78 ~~147.43~~

TECHNICAL APPENDIX F

GRANT APPLICATION PAYBACK SCHEDULE

All facts, tests and observations outlined below herein coupled with accepted manufacturer's test data established the basis for the energy grant. The energy grant justification, as it specifically applied to Tompkins Cortland Community College, was supported by the following formuli for simple "payback." Although the square footage and conditions are unique to this College, the simple payback rationale may be translated to most conditions.

"Drapes" as used in the schedule refer specifically to the "Thermofold" system.

"Treatment B" as used in the schedule refers specifically for bidding purposes, to "Seco Thermoshade" or equivalent naturals including, but not limited to: "High R" insulating shade or multi-layer window shade as manufactured by Insulating Shade Co., Guilford, CT., and "Window Quilt" as manufactured by Appropriate Technologies Corporation, Brattleboro, VT.

"Treatment C" as used in the schedule refers specifically to ¼" clear acrylic sheet.

APPENDIX F

Single Pane With Drapes

Area: 21,120 S.F.

Existing	New
R = .88	R = 2.4
U = 1.13	U = .42

U = .71
T = 68
BTU = 1,019,673

Single Pane With Treatment 'B'

Area: 2,334 S.F.

Existing	New
R = .88	R = 4.8
U = 1.13	U = .208

U = .92
T = 68
BTU = 146,015

Double Pane With Treatment 'B

Area: 6,432 S.F.

Existing	New
R = 1.72	R = 5.64
U = .58	U = .18

U = .4
T = 68
BTU = 174,950

Single Pane With Treatment 'C'

Area: 351 S.F.

Existing	New
R = .88	R = 3.2
U = 1.13	U = .31

U = .82
T = 68
BTU = 19,572

24 = hours in day
d = 311 days in heating season
t_a = 41.3°F average temperature during heating season
t_o = 0°F outdoor design
t_i = 68°F indoor design

$$H = \frac{24\ h \times 311 \times (68 - 41.3)}{68 - 0} \qquad H = \frac{h \times 199288.8}{68}$$

$$H = h \times 2{,}930.7$$

Estimated ECM Potential Energy Savings Single Pane With Drapes

H = 2,988,355,661 BTU/yr.

Single Pane With Treatment 'B'

H = 427,926,160.5

Double Pane With Treatment 'B'

H = 512,725,965

APPENDIX F

Single Pane With Treatment 'C'

H = 57, 359, 660

Conversion Factors BTU/3412

H = 1,168,332.54 KWH Yr. Total

Single Pane Drapes H = 875,836.95 KWH/yr
Single Pane Treatment 'B' H = 125,417.98 KWH/yr
Double Pane Treatment 'B' H = 150,271.38 KWH/yr
Single Pane Treatment 'C' H = 16,806.23 KWH/yr

Savings in dollars @ .04 /KWH = $46,733.30

Window Heaters

Total Load Per Linear Foot = 200 W
Linear Foot = 2730 L.F.
Total Load = $546{,}000 \times \frac{2930.7}{2} = 800{,}081{,}100$ W

800,081 KWH
Savings in dollars @ .04 /KWH = $32,003.24

Total Savings = $78,064.28

Estimated Implementation Cost

Drapes:	21,120 S.F. x 3.75 =	$79,200.00
Treatment 'B':	8,766 S.F. x 6.87 =	60,222.42
Treatment 'C':	351 S.F. x 6.00 =	2,106.00
		$141,528.42
+ 10% Architectural fees		14,152.84
		$155,681.26

- Capital Cost = $155,681.26
- Annual Energy Savings = $78,736.54
- Simple Payback = 1.97

JAN 15, 1982

ERIC Clearinghouse for Junior Colleges
96 Powell Library Building
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Los Angeles, California 90024